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TOKEN REINFORCEMENT, CHOICE, AND SELF-CONTROL IN PIGEONS

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Pigeons were exposed to self-control procedures that involved illumination of light-emitting diodes (LEDs) as a form of token reinforcement. In a discrete-trials arrangement, subjects chose between one and three LEDs; each LED was exchangeable for 2-s access to food during distinct posttrial exchange periods. In Experiment 1, subjects generally preferred the immediate presentation of a single LED over the delayed presentation of three LEDs, but differences in the delay to the exchange period between the two options prevented a clear assessment of the relative influence of LED delay and exchange-period delay as determinants of choice. In Experiment 2, in which delays to the exchange period from either alternative were equal in most conditions, all subjects preferred the delayed three LEDs more often than in Experiment 1. In Experiment 3, subjects preferred the option that resulted in a greater amount of food more often if the choices also produced LEDs than if they did not. In Experiment 4, preference for the delayed three LEDs was obtained when delays to the exchange period were equal, but reversed in favor of an immediate single LED when the latter choice also resulted in quicker access to exchange periods. The overall pattern of results suggests that (a) delay to the exchange period is a more critical determinant of choice than is delay to token presentation; (b) tokens may function as conditioned reinforcers, although their discriminative properties may be responsible for the self-control that occurs under token reinforcer arrangements; and (c) previously reported differences in the self-control choices of humans and pigeons may have resulted at least in part from the procedural conventions of using token reinforcers with human subjects and food reinforcers with pigeon subjects.

Key words: choice, self-control, reinforcer amount, reinforcer delay, token reinforcement, key peck, pigeons

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Experimental analyses of self-control typically involve a choice between a larger, delayed reinforcer and a smaller, more immediate reinforcer (Ainslie, 1974; Mischel, 1966; Rachlin & Green, 1972). Choice of the delayed reinforcer has been defined as *self-control* and choice of the immediate reinforcer as *impulsiveness.* Under a wide range of conditions, pigeons have almost invariably selected a greater number of smaller, more immediate reinforcers than larger, delayed reinforcers, even when it is at the expense of reinforcer amount in the long run (see review by Logue, 1988).

In contrast to the typical findings with pigeons as subjects, human subjects studied in laboratory settings are often said to exhibit self-control. Logue, Peña-Correal, Rodriguez, and Kabela (1986), for example, exposed adult humans to choices between varying amounts and delays in presentation of points that were later exchangeable for money. When faced with a choice between a small, relatively immediate reinforcer and a larger, more delayed reinforcer, all subjects made a greater number of delayed-reinforcer choices than is characteristically made by pigeons. In 30 of 38 cases, subjects selected the delayed reinforcer more often than the immediate reinforcer. These findings are consistent with those of several other studies in which adult humans' choices tended toward maximizing

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overall obtained reinforcement and were generally less sensitive than pigeons' choices to the effects of reinforcer delay (e.g., Belke, Pierce, & Powell, 1989; Flora & Pavlik, 1992; Logue, King, Chavarro, & Volpe, 1990).

Various interpretations have been proposed to account for these differences in self-control between humans and nonhumans. Some appeal to qualitative species-typical differences, such as verbal and rule-governed behavior, which are said to modulate sensitivity to environmental events (e.g., Horne & Lowe, 1993; Sonuga-Barke, Lea, & Webley, 1989). Others point to more quantitative differences, such as differences in the way delayed events diminish in their effectiveness as reinforcers for different species (Green, Fry, & Myerson, 1994; Herrnstein, 1981; Rachlin, Raineri, & Cross, 1991; Rodriguez & Logue, 1988). Both of these lines of interpretation are plausible and may have some merit; at present, however, they are confounded by procedural differences among studies, of which the observed species differences also may be partly a function. Only by investigating such procedural differences can the independent contributions of verbal functioning or any other species-typical characteristics to human-nonhuman differences in experimental results be determined.

A key procedural difference that distinguishes human from nonhuman experimentation concerns the nature of the consequences of choice responding and, concomitantly, the motivational conditions that establish and maintain the effectiveness of those consequences (Belke et al., 1989; Logue & King, 1991; Ragotzy, Blakely, & Poling, 1988; Zeiler, 1993). In studies with nonhuman subjects, consequences typically consist of food, a reinforcer with immediate consummatory value. In studies with human subjects, on the other hand, consequences most often consist of points that are exchangeable for money some time after the experimental session. Because points cannot be exchanged or "consumed" immediately and because delays to opportunities to exchange those points for other reinforcers are usually the same regardless of choice patterns within experimental sessions, there is no particular advantage to obtaining points quickly. This situation may bias in-session choice toward the large reinforcer.

As Hyten, Madden, and Field (1994) have recently suggested, the typical arrangement of consequences in studies with adult human subjects may be viewed as a token reinforcement system (Gollub, 1977; Kelleher, 1958; Malagodi, 1967), with points serving as token reinforcers. Although token reinforcers normally are physically manipulable objects (e.g., coins, poker chips, marbles), they can be defined more generally as conditioned reinforcers "that the organism may accumulate and later exchange for other reinforcers" (Catania, 1992, p. 400), a definition that would include points later exchangeable for money. Tokens are usually exchanged during distinct exchange periods, during which a specified exchange response involving the tokens is followed by presentation of some other terminal reinforcer. Thus, a token reinforcement system consists of a series of three successive schedules of reinforcement: (a) one in which tokens are obtained, (b) one in which the opportunity to exchange tokens is presented, and (c) one in which exchange responses produce the terminal reinforcer (Malagodi, Webbe, & Waddell, 1975; Waddell, Leander, Webbe, & Malagodi, 1972; Webbe & Malagodi, 1978).

The vast majority of prior research with human subjects has defined self-control and impulsiveness with respect to choices in the first schedule—the schedule of token (point) reinforcement. Past research on token-reinforced behavior, however, suggests that the token schedule is subordinate to contingencies arranged in later links of the chain in the control of behavior; the tokens derive their reinforcing function from the terminal reinforcer that is available only during exchange periods (e.g., Kelleher, 1958; Malagodi et al., 1975; Waddell et al., 1972; Webbe & Malagodi, 1978). This view deemphasizes the importance of the token delivery schedule and implies that the scheduling of exchange periods may be a more critical determinant of behavior. This is consistent with the results reported by Hyten et al. (1994), in which the choice patterns of human subjects depended on the delays to exchange periods (during which money was available) but not on delays to the delivery of tokens (points). Interestingly, if money is viewed as the relevant reinforcer in experiments with human subjects, many findings are consistent with those from experiments with nonhuman subjects showing that behavior is sensitive to reinforcer amount when reinforcer delays are held constant (e.g., Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Mazur, 1987).

The present experiments investigated pigeons' choices in a self-control arrangement with token-like reinforcers in an effort to approximate more closely the procedures typical of laboratory experimentation with adult human subjects. Choices resulted in the illumination (delivery) of either one or three light-emitting diodes (LEDs), which served as token reinforcers. Each LED could be exchanged for 2-s access to food during discrete posttrial exchange periods. The larger reinforcer (three LEDs) normally was delayed by 6 s, whereas the smaller reinforcer (one LED) was delivered immediately. In Experiments 1 and 2, exchange periods initially were scheduled after each choice trial. The ratio of choice trials to exchange periods was then increased systematically across phases until a single exchange period was scheduled at the end of the session. This final condition was seen as most closely analogous to experiments with human subjects, in which points are exchanged for other reinforcers (usually money) at the end of a session. In Experiment 2, the relative influence of delays to LED presentation (LED delays) and delays to the exchange period (exchange delays) was investigated. The major manipulations of Experiment 1 were replicated with exchange delays from either choice option equal under most conditions but unequal under others. In Experiment 3, the function of the LEDs was investigated by examining choices with and without corresponding LED illumination. In other conditions, subjects chose between equal numbers of but unequal delays to LED presentation. In Experiment 4, sensitivity to exchange delays was reexamined during self-control arrangements in which an exchange period occurred after each trial. The delays to the exchange periods were equal for both options during some conditions and unequal under others. Collectively, these four experiments were designed to fill a key methodological gap that has separated experiments on self-control with humans from those with nonhumans, and thereby help to determine the extent to which previously reported species differences in performance may be related to differences in procedure.

EXPERIMENT 1

In this experiment, pigeons were given choices between one LED delivered immediately and three LEDs delivered after a 6-s delay. Exchange periods were initially scheduled after each choice trial, but were gradually made more intermittent across phases until a single exchange period occurred at the end of an experimental session. Increasing the trial:exchange ratio in successive phases was done to encourage the establishment of the LEDs as conditioned reinforcers by initially pairing LED presentation with food availability. Gradually increasing this ratio was also expected to minimize the response-weakening effects of intermittent exchange-period scheduling (Waddell et al., 1972), while at the same time establishing a rich history of correspondence between the number of tokens and the number of terminal reinforcers—a history that is presumed to be already in place prior to an adult human subject's participation in a laboratory experiment.

METHOD

Subjects

Six experimentally naive male White Carneau pigeons (*Columba livia*) served as subjects. All birds were individually housed with water and health grit continuously available. Free-feeding weights were obtained by first providing free access to mixed grain in the home cage for a period of at least 2 weeks. At this point, the heaviest of the last three consecutive daily weights was defined as the free-feeding weight. Birds were maintained at approximately 80% of their free-feeding weights throughout the experiment. The maintenance weights for each bird were 498 g for Bird 1857, 427 g for Bird 747, 467 g for Bird 1383, 533 g for Bird 1732, 514 g for Bird 1855, and 450 g for Bird 753.

Apparatus

A standard three-key Lehigh Valley pigeon chamber with a modified stimulus panel served as the experimental space. A minimum force of 0.14 N activated either side key, and a minimum force of 0.12 N activated the center key. A row of 34 evenly spaced red LEDs was recessed into the panel 4.75 cm above the keys. The row was centered 1.7 cm from each end of the panel. Unless otherwise indicated, illumination of LEDs always proceeded sequentially from left to right, with each onset accompanied by a brief tone. The LEDs always were turned off sequentially from right to left. The left, center, and right keys could be illuminated green, red, and blue, respectively. Primary reinforcement consisted of access to mixed grain through an aperture in the stimulus panel. During food delivery, all keylights and the houselight were dark, and an orange light above the feeder was illuminated. White noise was present in the experimental room to mask extraneous sounds. Experimental contingencies were scheduled and data recorded on a standard microcomputer with MED-PC® software (Tatham & Zurn, 1989) and interfacing in an adjacent room.

Procedure

Initial training. Each bird first was exposed to a 1-hr session of adaptation with the houselight and all LEDs illuminated but no other programmed contingencies in effect. Next, during magazine training and exchange key-peck shaping, the number of illuminated LEDs corresponded to the number of food deliveries available. Magazine training sessions began with the simultaneous illumination of the leftmost 17 LEDs, the white houselight, and the red center key (exchange key). Intermittent hopper presentations were controlled by a hand-held switch. When operated, the switch turned off one LED and 0.5 s later produced food. The next switch operation withdrew the hopper. Magazine training ended when the bird ate readily from the feeder for at least five consecutive food deliveries.

Training the pigeon to peck the exchange key (exchange response) began with the same stimulus conditions as magazine training. Successive approximations to key pecks on the exchange key turned off one LED, followed 0.5 s later by a 2-s food delivery. Once an exchange response had occurred, each remaining food delivery of the session required a single peck on the illuminated exchange key. All birds were then exposed to two sessions of 34 LED exchanges each, with the same contingencies programmed on the exchange key.

Throughout the remainder of the experiment, the exchange key was operable only during discrete posttrial exchange periods. During exchange periods, a single exchange response turned off the exchange key and one LED, followed 0.5 s later by 2 s of food. Exchange periods were initiated by illumination of the exchange key and remained in effect until all illuminated LEDs were exchanged.

Choice-key training began with the illumination of the houselight and one of the two side keys. Each bird was exposed to two sessions of 34 food deliveries each, with a different choice key available in each session. A single peck on the illuminated choice key turned off the key and turned on one LED, followed 0.1 s later by an exchange period. For Bird 1857, which did not peck the choice key after 180 min in the chamber, pecking was established by reinforcing successive approximations to pecking the choice key with the onset of an LED followed by the exchange period.

Experimental procedure. Throughout the remainder of the experiment, two sessions were scheduled daily, 5 days per week, with a 5-min blackout between sessions. Each session consisted of two forced-exposure trials followed by 10 free-choice trials. Each trial began 60 s from the onset of the preceding trial, excluding exchange periods. Failure to respond for 45 s on a given trial delayed the onset of the next trial an additional 60 s. During the intertrial interval (ITI), the houselight and all keylights were dark.

The forced-exposure trials were designed to bring behavior into contact with the consequences that had been programmed on both keys. The key available on the first trial (left or right) was determined randomly with a probability of .5; the alternate choice key was automatically illuminated on the second trial. The contingencies that were correlated with the illuminated key on forced-choice trials corresponded to those in effect on choice trials.

Choice trials began with the illumination of the houselight and both side (choice) keys. A single peck on either side key (choice response) darkened both keys and produced the associated consequences, the illumination of either one or three LEDs. Small-reinforcer choices resulted in the immediate illumination of one LED. Large-reinforcer choices resulted in the illumination of three LEDs—one immediately, the other two spaced 0.6 s apart. Thus, it took 1.2 s to deliver three LEDs. Figure 1 shows the sequence of events following large- and small-reinforcer choices.

All birds were initially exposed to a choice between one and three LEDs scheduled immediately, with an exchange period following each trial (designated Condition 1). When scheduled, exchange periods always began 0.1 s after the last LED presentation. Thus, exchange periods followed small-reinforcer (one LED) choices by 0.1 s and large-reinforcer (three LEDs) choices by 1.3 s.

Next, birds were randomly assigned to one of two groups of 3 subjects each. Table 1 summarizes for each bird the experimental conditions, order of exposure, and number of sessions conducted at each. For birds in Group A, large-reinforcer choices produced three LEDs after a 6-s delay (Condition 1D). The ratio of choice trials to exchange opportunities was then increased to 2:1, 5:1, and 10:1 across Conditions 2D, 5D, and 10D, respectively. For birds in Group B, the ratio of trials to exchange periods was first increased from 1:1 to 2:1 to 5:1 to 10:1, before adding the 6-s delay to the large reinforcer in the final condition (10D). Condition designations were codes designed to function as mnemonic devices, with the number indicating the number of choice trials before an exchange period and the D indicating a 6-s delay in presentation of the three LEDs (i.e., the large reinforcer).

The LEDs remained illuminated during the ITI after trials with no scheduled exchange period; the number of illuminated LEDs accumulated over successive trials until the next exchange period. Whenever the ratio of choice trials to exchange periods was greater than 1:1, only the second of the two forced-choice trials was followed by an exchange period. The large reinforcer was arbitrarily assigned to the left key for 3 birds (747, 1383, 753) and to the right key for the other 3 birds (1857, 1732, 1855). This assignment was constant throughout the experiment.

Experimental phases were in effect for at least 20 sessions and until the following stability criteria were met: (a) No trends were evident in the number of choices allocated to either alternative over the last 10 sessions, and (b) the number of choices of either option during the last five sessions was not outside the range of values obtained during all previous sessions. In one case (Bird 1732, Condition 10), conditions were changed after 80 sessions when the latter criterion was met but the former criterion was not.

RESULTS

Figure 2 shows the mean number of large-reinforcer choices per session across all conditions. Because a session consisted of 10 trials, a value above five indicates preference for the larger reinforcer, whereas a value below five indicates preference for the smaller reinforcer. A mean value between four and six, with a range that extends above and below five, indicates indifference. (The term *preference* in this context is used in a purely descriptive sense, referring to the relative number of small and large reinforcers, and should not be taken to imply a process underlying behavior.)

Condition 1, with no delay to the reinforcer in either group, resulted in strong preference for the large reinforcer in 5 of the 6 birds (only Bird 1857 in Group A preferred the small reinforcer). When the large reinforcer was delayed 6 s in Condition 1D, preference reversed in favor of the small reinforcer for the 2 birds that had preferred the large reinforcer in Condition 1. All 3 birds in Group A preferred the smaller, more immediate reinforcer across Conditions 1D, 2D, 5D, and 10D. This preference was generally strong, with an average of less than two large-reinforcer choices per session; the only two exceptions occurred during Condition 2D (the first condition in which the ratio of choice trials to exchange periods increased) in which the mean number of large-reinforcer choices increased to three and four for Birds 1857 and 1383, respectively.

For birds in Group B, scheduling the exchange period every second choice trial reduced preference for the large reinforcer for Birds 1732 and 1855, but not for Bird 753. Further increases in the number of choice trials per exchange period during Conditions 5 and 10 shifted preference in favor of the

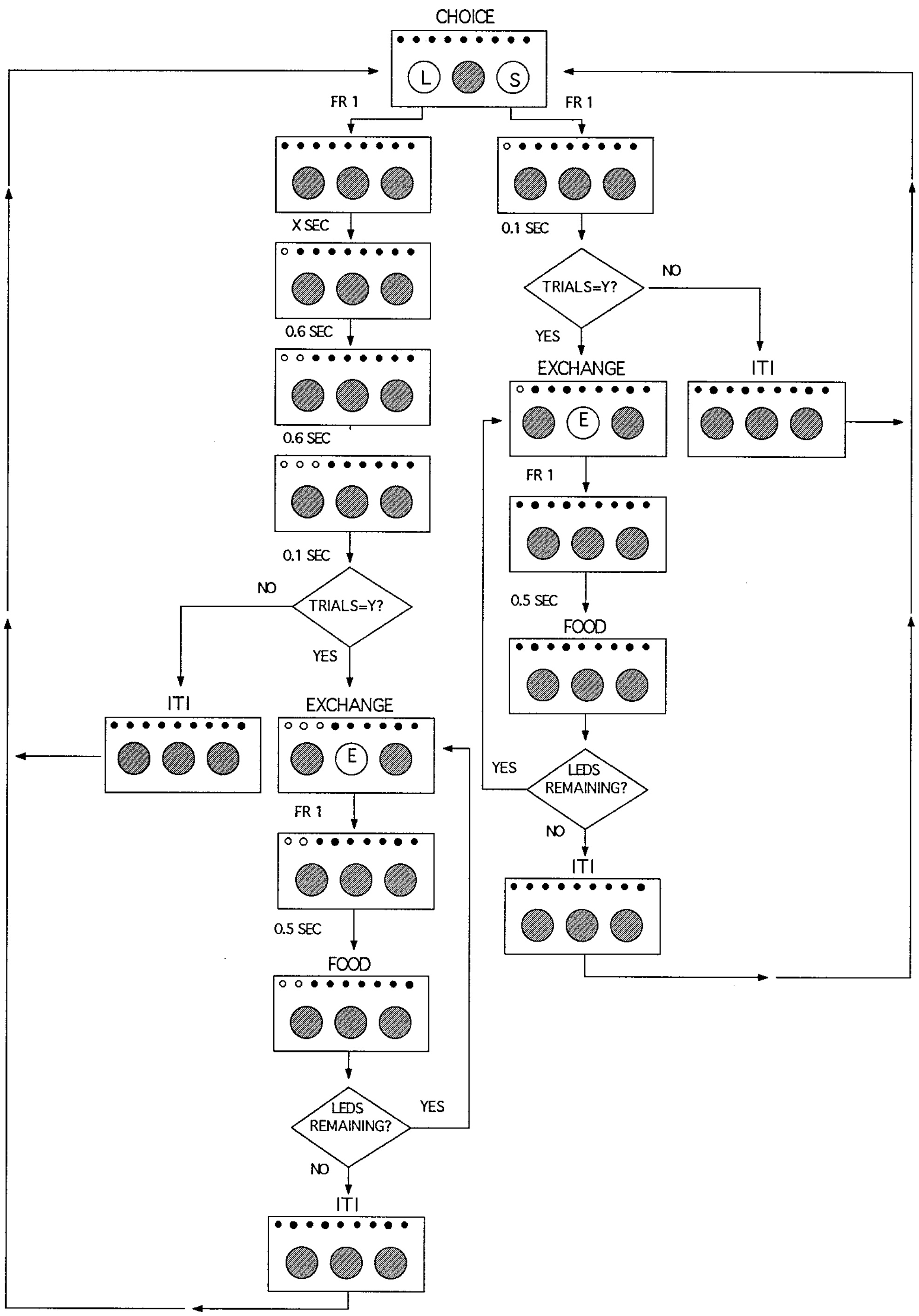

Fig. 1. Flow chart depicting the within-trial sequence of events following choice of the large (L) and small (S) reinforcers in Experiment 1. The number of choice trials per exchange period is given by Y, which assumed values of 1, 2, 5, or 10, depending on the condition. The delay to the presentation of the first LED following a large-reinforcer choice is given by X, which assumed a value of 0 or 6 s, depending on the condition.

Table 1

Number of sessions per experimental condition (listed in order of exposure) for all birds in Experiment 1.

Bird		Condition[a]				
		1	1D	2D	5D	10D
Group A	1857	30	20	36	20	22
	747	26	20	28	20	32
	1383	20	20	30	20	40
		Condition				
		1	2	5	10	10D
Group B	1732	32	60	78	80[b]	38
	1855	21	50	22	32	28
	753	42	32	58	36	26

[a] The numbers 1, 2, 5, and 10 refer to the number of choice trials per exchange period. D indicates a 6-s delay to the large reinforcer (three LEDs).

[b] Did not meet stability criteria.

small reinforcer for Birds 1855 and 753. The magnitude of this effect was greater in Bird 753, who in the previous two conditions had chosen the large reinforcer on nearly all trials. For Bird 1732, preference for the large reinforcer recovered during Conditions 5 and 10, but reversed in favor of the small reinforcer when a delay to the large reinforcer was added in Condition 10D. This added delay also resulted in fewer large-reinforcer choices for Bird 753. For Bird 1855, the number of large-reinforcer choices remained at approximate indifference during this condition.

Taken together, the data for Groups A and B show that birds made fewer large-reinforcer choices when presentation of the three LEDs was delayed than when it was immediate. None of the 5 birds that initially preferred the large reinforcer continued to do so when it was delayed. For 3 of these birds (747, 1383, and 1732), adding the delay to the large reinforcer reversed preference from the large to the small reinforcer.

Figure 3 shows within-session choice patterns. The relative frequency of large-reinforcer choices is plotted across trials. For birds in Group A, the greatest proportion of large-reinforcer choices tended to occur during the first trial of a block of trials that preceded an exchange period, and generally decreased across trials. Similar, although less consistent, effects occurred with birds in Group B. The relative number of large-reinforcer choices was greatest during the initial trial of the block in 8 of 12 cases for the 3 birds, and decreased to lower levels across remaining trials.

Figure 4 shows average choice latencies from the last 10 sessions of conditions in which exchange periods were scheduled after two or more trials. In 38 of 40 cases across birds, latencies were longest during the first trial of a block, decreasing across trials. The first-trial latencies also tended to be longer as the number of choice trials per exchange period was increased across conditions. With one exception (the second trial of Condition 10D for Bird 1732), the longest latency for each bird occurred on the first trial in conditions with exchange periods scheduled after the 10th choice trial. Birds 747 (Condition 10D) and 1855 (Condition 10) regularly had first-trial choice latencies longer than 45 s, which postponed the onset of the 2nd trial by 45 s.

Discussion

Pigeons' choices were assessed in a self-control arrangement with token-like reinforcers. Despite the procedural similarities of this arrangement to typical procedures with human subjects, the overall results are more consistent with previous findings from experiments with pigeon subjects than with those from experiments with adult human subjects (Logue, 1988). That is, birds usually responded impulsively, preferring the smaller, more immediate token reinforcer to the larger, more delayed token reinforcer (Figure 2).

Although the results are seemingly at odds with those obtained in token reinforcer procedures with adult humans, a careful examination of the temporal relations between choices and the scheduling of exchange periods reveals an alternative explanation of the results. Exchange periods occurred immediately after the LEDs were presented, and it always took longer to deliver three LEDs than to deliver one LED. Thus, on trials just prior to an exchange period, the two options differed not only in delays to LED presentation but also in delays to the exchange period.

Considering just the self-control conditions (1D, 2D, 5D, and 10D), in which the three LEDs were delayed and the single LED option was more strongly preferred, exchange periods began 0.1 s after a small-reinforcer

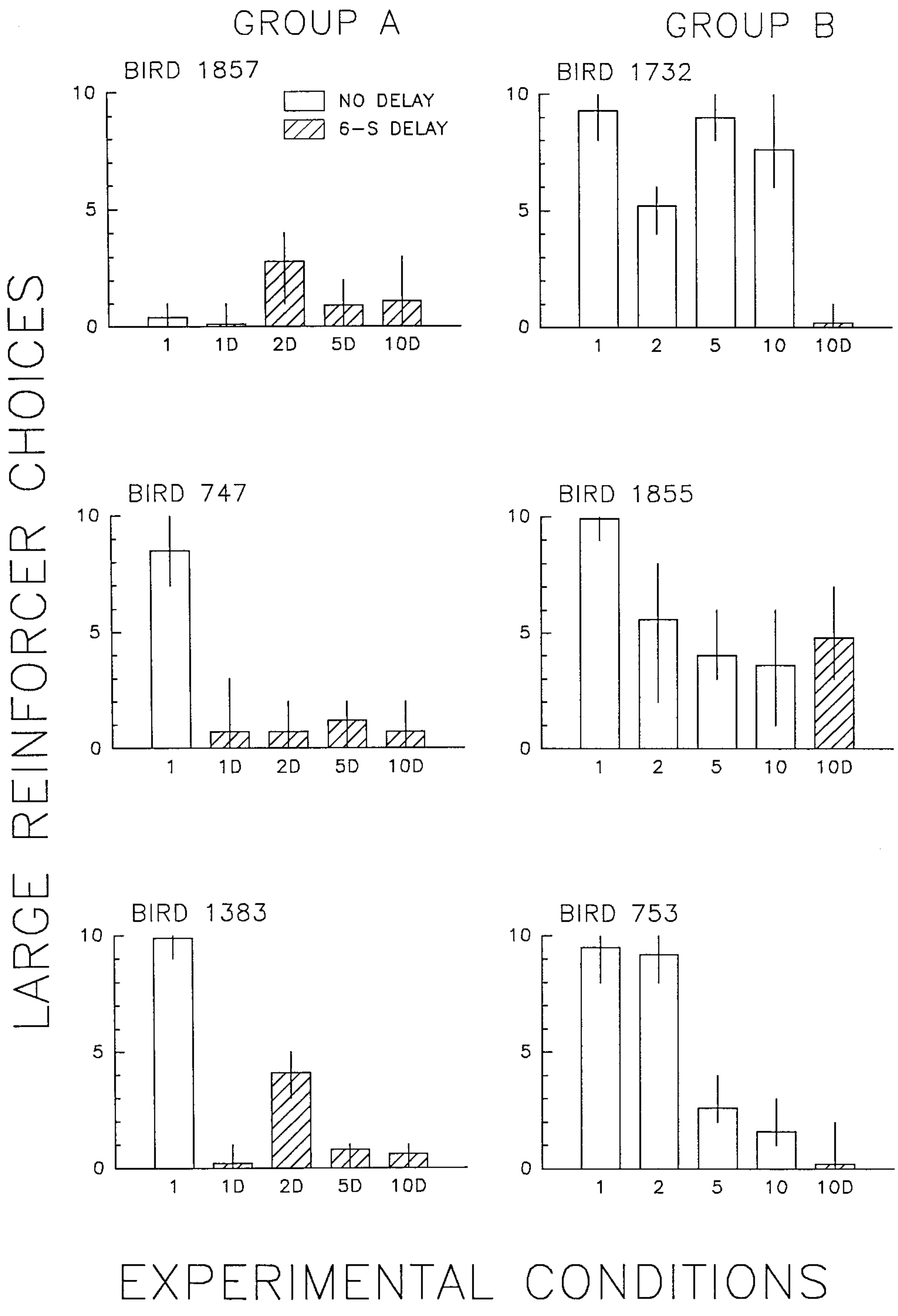

Fig. 2. Mean number of large-reinforcer choices per session from the last 10 sessions of each condition of Experiment 1. Condition designation numbers indicate the number of choice trials per exchange period; the D indicates a 6-s delay in presentation of the large reinforcer (three LEDs). Data from birds in Group A are shown in the left panels, and data from Group B are shown in the right panels. Vertical lines show the range of values used to determine the mean. Open bars correspond to conditions with no delay to the large reinforcer. Striped bars correspond to conditions with a 6-s delay to the large reinforcer.

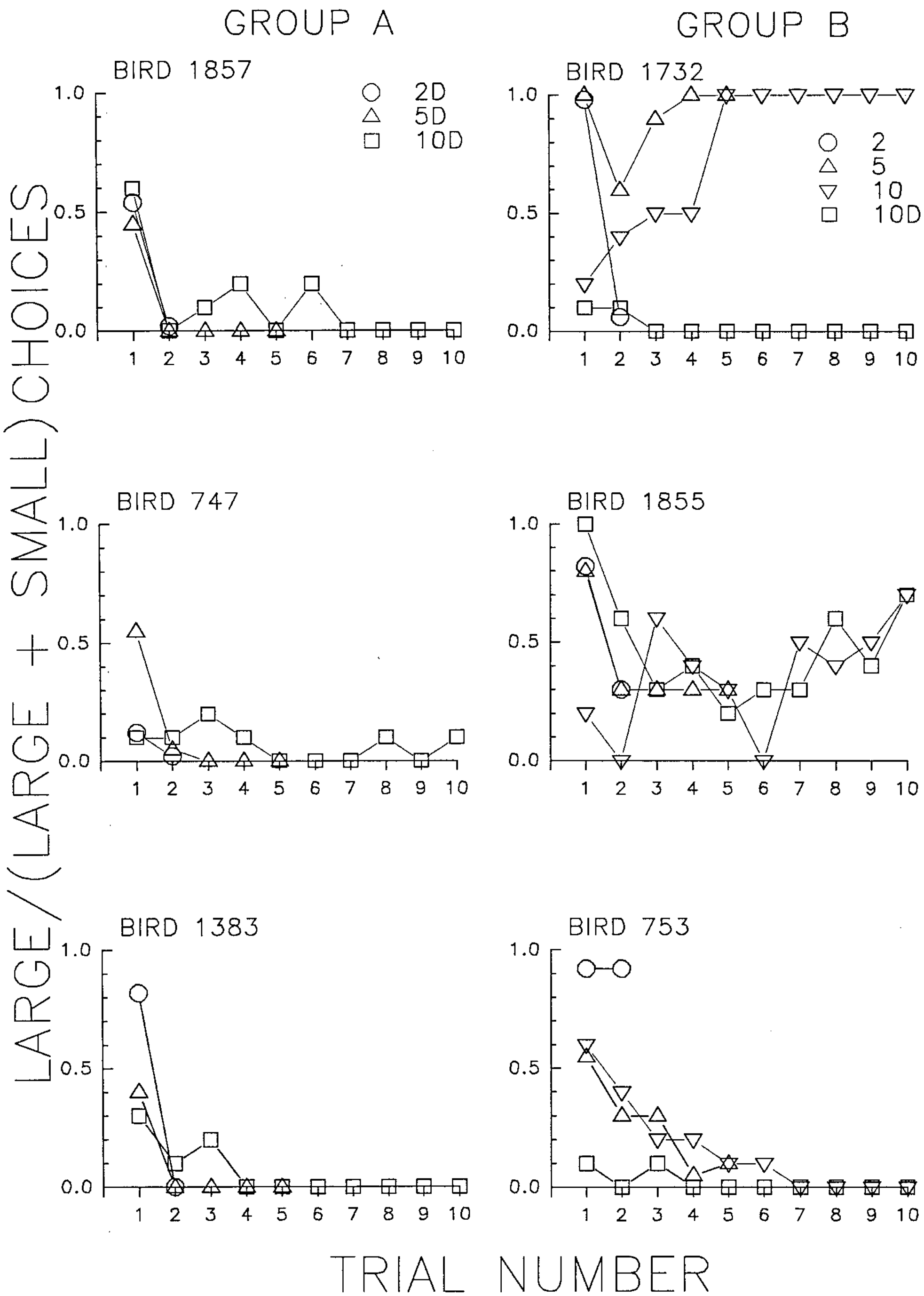

Fig. 3. The relative frequency of large-reinforcer choices plotted across trials that preceded scheduled exchange periods over the final 10 sessions of conditions of Experiment 1 in which exchange periods occurred after two or more choice trials. Condition designation numbers indicate the number of choice trials per exchange period; the D indicates a 6-s delay in presentation of the large reinforcer (three LEDs). Data from birds in Group A are shown in the left panels, and data from Group B are shown in the right panels.

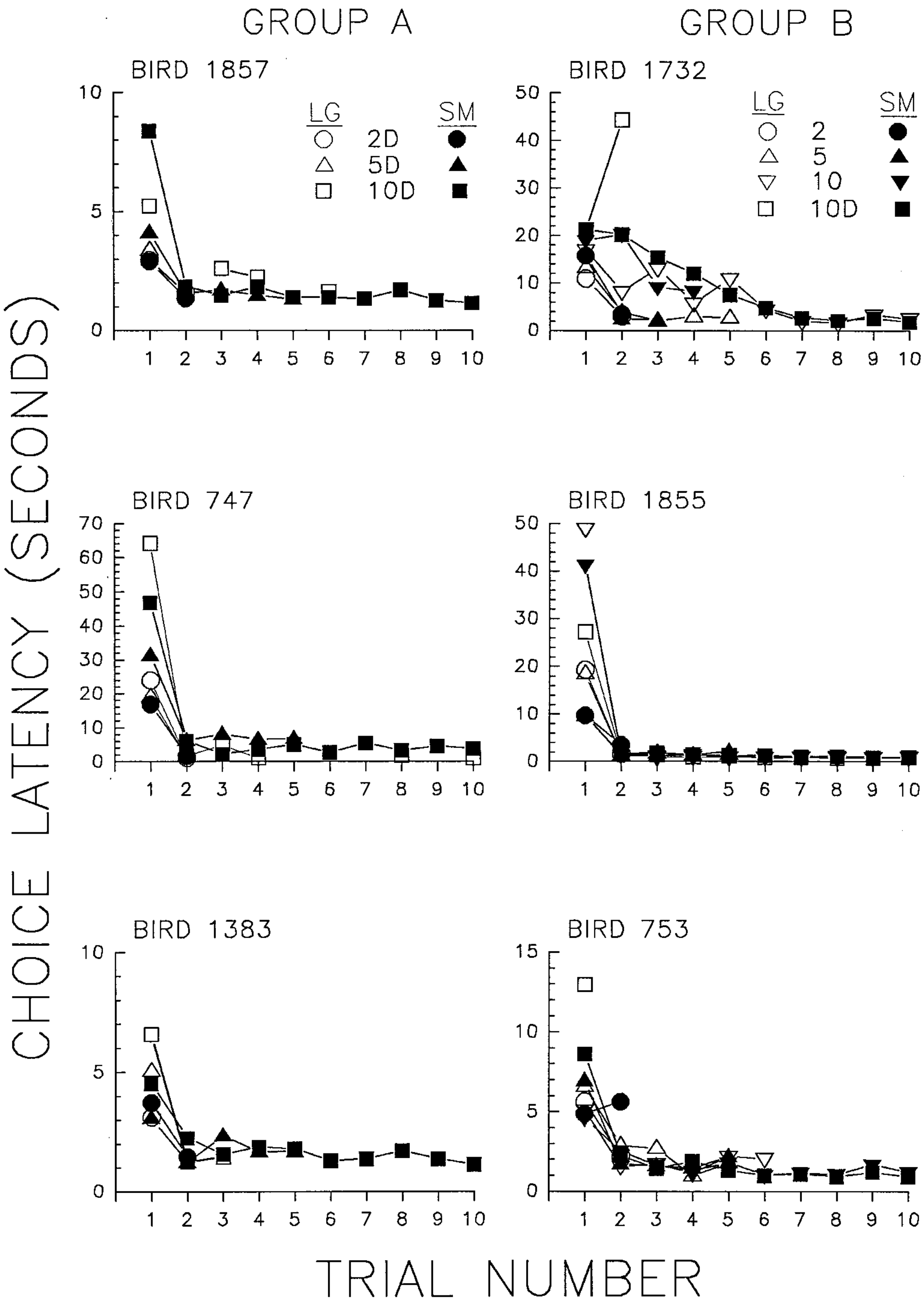

Fig. 4. Mean choice latencies across the final 10 sessions of conditions of Experiment 1 in which exchange periods were scheduled after two or more choice trials. Condition designation numbers indicate the number of choice trials per exchange period; the D indicates a 6-s delay in presentation of the large reinforcer (three LEDs). Open symbols represent latencies for large-reinforcer choices, and filled symbols represent those for small-reinforcer choices. Data from birds in Group A are shown in the left panel, and data from Group B are shown in the right panel. The *y* axes are scaled individually to accommodate between-subject differences. The absence of a data point for either choice denotes conditions in which choices of that type did not occur.

choice but 7.3 s after a large-reinforcer choice. Smaller differential delays to the exchange period occurred when LED delivery was immediate for both options (Conditions 1, 2, 5, 10). Here, when scheduled, exchange periods began 0.1 s after a small-reinforcer choice but 1.3 s after a large-reinforcer choice. The greater number of small-reinforcer choices under conditions in which the large reinforcer was delayed, and the overall impulsive pattern of choices, might have resulted from the greater delay to exchange periods following large-reinforcer choices rather than from the delay to LED presentation. Viewed in this way, the results are consistent with previous findings with pigeons regarding sensitivity of choices to delays in food availability, but are ambiguous with respect to sensitivity of choices to delays in token delivery.

The importance of differential delays to the exchange period is illustrated best in the choice patterns obtained during Conditions 2 and 2D (in which exchange periods occurred every second trial). Here, choice responding on the first trial of a block had no effect on exchange period availability, and a greater proportion of large-reinforcer choices occurred on the first trial of a block than on the second trial in 5 of the 6 birds (Figure 3). For 4 birds, a clear reversal of preference favoring the smaller reinforcer occurred on the second trial, in which choice of the small reinforcer also resulted in quicker access to the exchange period.

The influence of differential delays to the exchange period was less evident in the results from later conditions in which exchange periods occurred after five or 10 trials. Only on the final trial of a block (i.e., the trial just before the exchange opportunity) did exchange delays favor small-reinforcer choices, yet most birds preferred the small reinforcer across the earlier trials as well. Stimulus generalization, based on the presence versus absence of illuminated LEDs, may have played a role here. At least some LEDs were illuminated on all trials except the first trial of a block. Control of small-reinforcer choices on the final trial of a block may have generalized across the earlier trials with LEDs present, resulting in an overall impulsive pattern of responding.

The within-session pattern of choices (Figure 3) and latencies (Figure 4) supports the view that the presence or absence of LEDs contributed to the choice patterns. The probability of a large-reinforcer choice was highest and the latency to that choice was longest on the first trial of a block—the trial most temporally remote from the exchange period and the trial in which the stimulus conditions were most unlike those on the final trial of the block. With but a few exceptions, the probability of large-reinforcer choices was low and latencies were short and nearly equal across the remaining trials in which illuminated LEDs were always present.

EXPERIMENT 2

Given the well established sensitivity of pigeons' choices to even small differences in delays to food (e.g., Chung & Herrnstein, 1967; Green, Price, & Hamburger, 1995; Logue et al., 1984; Mazur, 1987), it is not surprising that unequal delays to exchange periods (and hence to food) also affected responding in Experiment 1. In fact, small differences in delays to exchange periods precluded a clear assessment of the relative influence of LED reinforcement versus food reinforcement. To distinguish these separate potential sources of reinforcement, the major manipulations of Experiment 1 were replicated in Experiment 2 in the same subjects, with the delay to exchange periods from either choice option equal under most conditions but unequal under others.

Method

Subjects and Apparatus

The pigeons from Experiment 1 served as experimental subjects. Housing, feeding arrangements, and apparatus were the same as in Experiment 1.

Procedure

Group and choice-key reinforcer assignments were the same as in Experiment 1. Condition designation codes were similar to those of Experiment 1, with an E indicating equal delays to the exchange period during conditions in which the large reinforcer was delayed and an R designating a condition in which choice-key contingencies were reversed.

All birds were initially exposed to an arrangement similar to Condition 1 of Experiment 1 (also designated Condition 1), except that the exchange period occurred 1.5 s from either choice response. For birds in Group A, the large reinforcer was then delayed by 6 s; the exchange period thus occurred 7.5 s after a large-reinforcer choice but still occurred 1.5 s after a small-reinforcer choice (Condition D1). Beginning with the next condition (ED1), exchange periods were scheduled 9.5 s from either choice, with no change in LED presentation. Finally, the number of choice trials per exchange period was increased across conditions, as in Experiment 1, from 2 to 5 to 10 (designated ED2, ED5, and ED10, respectively).

After Condition 1, Group B birds were first exposed to increases in the ratio of trials to exchange periods across Conditions 2, 5, and 10, with exchange delays for both options held constant at 1.5 s. Then a 6-s delay was added to the large-reinforcer choice (D10). Under this condition, the exchange period occurred 7.5 s after a large-reinforcer choice but still occurred only 1.5 s after a small-reinforcer choice. In the next condition (ED10), the exchange period was scheduled 9.5 s from either choice.

Condition ED10 was viewed as most analogous to the self-control procedure typical of most experimentation with human subjects. For birds that preferred the delayed large reinforcer and thus exhibited self-control under these conditions, contingencies arranged on the two keys were reversed to rule out key bias as an explanation of the results. All birds in Group B and Bird 1857 from Group A were exposed to such reversals of contingencies (RED10), followed by a return to the original contingencies (ED10). The sequence of conditions and number of sessions conducted at each are summarized in Table 2. The same stability criteria were used as in Experiment 1.

Table 2

Experimental conditions, order of exposure, and number of sessions per condition for all birds in Experiment 2.

Condition[a]	Time from a choice response to the exchange period (seconds): Large reinforcer	Small reinforcer	Number of sessions		
			Group A		
			1857	747	1383
1	1.5	1.5	27	28	27
D1	1.5	7.5	50	22	44
ED1	9.5	9.5	60	24	28
ED2	9.5	9.5	32	34	64
ED5	9.5	9.5	47	30	70
ED10	9.5	9.5	77	21	46
RED10	9.5	9.5	42		
ED10	9.5	9.5	26		
			Group B		
			1732	1855	753
1	1.5	1.5	28	26	30
2	1.5	1.5	24	20	90
5	1.5	1.5	39	34	20
10	1.5	1.5	22	78	30
D10	1.5	7.5	33	22	42
ED10	9.5	9.5	26	80[b]	30
RED10	9.5	9.5	20	80[b]	36
ED10	9.5	9.5	40	34	106

[a] The numbers 1, 2, 5 and 10 refer to the number of choice trials per exchange period. D indicates a 6-s delay to the large reinforcer (illumination of three light-emitting diodes). E indicates an equal delay of 9.5 s from either choice response to a scheduled exchange period. R indicates that the contingencies were reversed for the choice keys.

[b] Did not meet stability criteria.

Results

Figure 5 shows the number of large-reinforcer choices across all experimental conditions for birds in both groups. All birds strongly preferred the large reinforcer in Condition 1, in which neither reinforcer was delayed and the exchange period occurred 1.5 s after each choice. For 2 birds in Group A (1857 and 747), preference reversed in favor of the small reinforcer when the large reinforcer was delayed by 6 s and the exchange period occurred 7.5 s after a large-reinforcer choice (D1). Bird 1383's performance was less sensitive to this change, in that only a small decrease in large-reinforcer choices occurred. During Condition ED1, in which the exchange period was scheduled 9.5 s from either choice, preference for the large reinforcer was recovered in Bird 1857 but not in 747. Bird 1383 continued to prefer the large reinforcer during this condition.

Increasing the ratio of trials to exchange produced different results among birds in Group A. The number of large-reinforcer

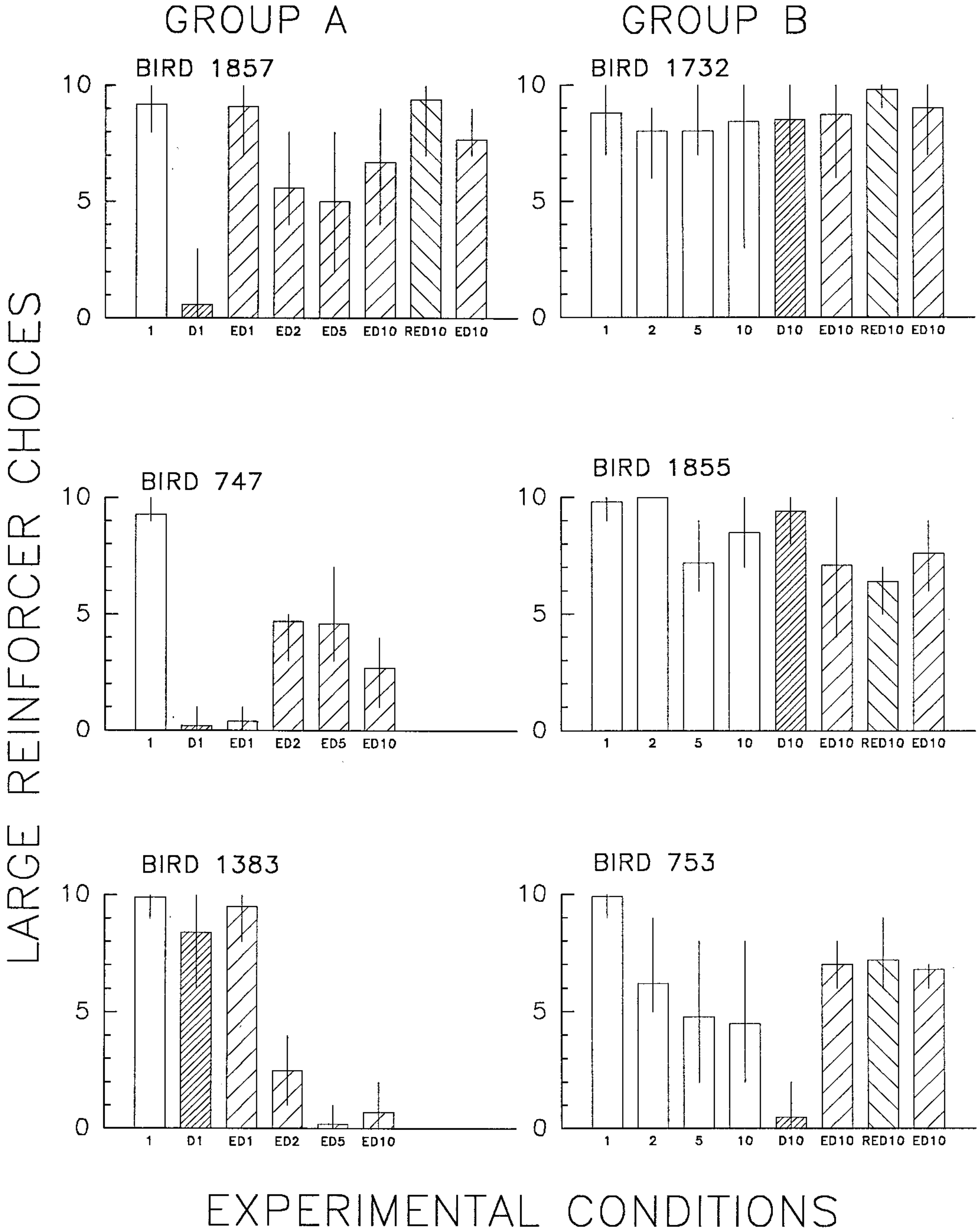

Fig. 5. Mean number of large-reinforcer choices per session from the final 10 sessions of each condition of Experiment 2 for both groups. Condition designation numbers indicate the number of choice trials per exchange period. The D indicates a 6-s delay in presentation of the large reinforcer (three LEDs), the E indicates equal delays to the exchange period from either choice option, and the R indicates a reversal of contingencies on the choice keys. Graphing conventions are the same as in Figure 2. The finely striped bars indicate the first condition with the large reinforcer delayed, the coarsely striped bars indicate equal delays to the exchange period from either choice, and the reversed coarse stripes indicate the reversal condition.

choices decreased for Bird 1857, resulting in indifference during Conditions ED2 and ED5, before increasing slightly during Condition ED10. Preference for the large reinforcer was maintained after reversing the keys (RED10) and after reinstating the original key contingencies in the final condition. Bird 1857 was the only bird in Group A to prefer the delayed large reinforcer in the terminal arrangement, in which a single exchange period was scheduled at the end of each session. Choice patterns in Bird 747 were roughly indifferent during Conditions ED2 and ED5 and favored the small reinforcer during Condition ED10. After preferring the large reinforcer with exchange opportunities after each trial, Bird 1383 preferred the small reinforcer across the remaining conditions (ED2, ED5, and ED10).

All 3 birds in Group B exhibited self-control in the terminal arrangement, in which the large reinforcer was delayed, exchange periods were scheduled after 10 trials, and there was an equal delay to the exchange period from either choice (Conditions ED10 and RED10). Birds 1732 and 1855 preferred the large reinforcer across all conditions, even when choice of the small reinforcer resulted in quicker access to the exchange period (D10). For Bird 753, preference for the large reinforcer decreased as the ratio of trials to exchange period was increased across Conditions 2, 5, and 10, resulting in indifference during the latter two conditions. Preference shifted to the small reinforcer when the large reinforcer was delayed (Condition D10) but then reversed sharply in favor of the large reinforcer in Condition ED10, in which the time to the exchange period from either choice was increased to 9.5 s.

Discussion

In contrast to the results of Experiment 1, self-control was obtained in 4 of the 6 birds during the terminal choice arrangement of Experiment 2, in which exchange delays were equal for both options. The results of this experiment are consistent with an interpretation based on sensitivity to exchange delay parameters, which implicate programmed delays to exchange periods as the crucial determinants of choice.

Across subjects, preference for the large reinforcer was observed in 27 of 38 conditions in which exchange delays were equal for both options across all trials of a block. Even in the exceptional cases in which the large reinforcer was not preferred, a greater number of large-reinforcer choices occurred than is characteristic of pigeons' choices in more typical self-control arrangements (e.g., Mazur & Logue, 1978). There also were, usually, more large-reinforcer choices during conditions of Experiment 2, in which exchange delays were equal, than during comparable conditions of Experiment 1, in which exchange delays favored small-reinforcer choices.

The predominance of exchange delays over LED delays was clearly demonstrated in the choice patterns of Bird 1857 (Figure 5). Preference for the small reinforcer occurred during Condition D1, in which presentation of the three LEDs was delayed 6 s and food could be obtained quicker by choosing the small reinforcer. When the delays to food were equated for both options during Condition ED1, however, preference reversed in favor of the large reinforcer, although LED presentation continued to be delayed 6 s following large-reinforcer choices. A similar effect occurred with Bird 753 across Conditions D10 and ED10 (Figure 5).

Unlike Birds 1857 and 753, the choice responding of 3 other birds (1383, Condition D1; 1732 and 1855, Condition D10) showed apparent insensitivity to differential exchange delays (Figure 5). Interestingly, the responding of both Birds 1732 and 1383 was sensitive to differential exchange delays during analogous conditions of Experiment 1 (Figure 2, Conditions 10D and 1D, respectively). Perhaps, as demonstrated in other experiments (e.g., Navarick & Fantino, 1976), the lower ratio of delays to food (i.e., the exchange period) from each choice in Experiment 2 accounts for this difference. For Bird 1855, a review of choice patterns across all sessions of Condition D10 of Experiment 2 (not shown) revealed that the small reinforcer was never chosen on the 10th trial of a block; hence, the shorter delay to food associated with that choice was never encountered.

EXPERIMENT 3

In Experiments 1 and 2, exchange delays predominated over LED delays in determining choice patterns, which may lead one to question the relevance of the LEDs per se to choices in the present arrangement. This question was investigated in Experiment 3 by exposing birds to conditions similar to the final condition of Experiment 2 (ED10), except that the LED display panel was sometimes rendered inoperable and the LEDs were not illuminated. If the LEDs were irrelevant to the birds' choices, those who previously preferred the option resulting in the greater amount of food should continue to do so, even in the absence of LED presentation.

A second question concerning the role of the LEDs is the degree to which choices are sensitive to differing delays in LED presentation when the two options do not differ in terms of reinforcer amount. That is, will birds prefer more immediate over delayed LED presentation when the number of LEDs (hence the amount of food) is the same for both options? This question was investigated during other conditions of Experiment 3, in which birds were given choices between three LEDs delivered immediately and three LEDs delivered after a delay. If the LEDs function as do other positive reinforcers such as food, then birds should prefer the immediate over the delayed delivery of LEDs when the overall number of LEDs is held constant.

METHOD

Subjects and Apparatus

Three of the 4 pigeons that preferred the larger reinforcer in the final three conditions of Experiment 2 (1857, 1732, and 1855) served as experimental subjects. A 4th bird (753) was eliminated early from this experiment when a key bias developed and attempts to reestablish choice responding that was characteristic of the final conditions of Experiment 2 failed. Housing, feeding arrangements, and apparatus were the same as in Experiments 1 and 2.

Procedure

There were three basic types of conditions in Experiment 3, with several control conditions designed to account for color and position bias. Condition NLED was like Condition ED10 of Experiment 2, except the LEDs were not illuminated and the auditory stimulus that previously accompanied LED illumination did not occur. That is, choice responses determined the number of food deliveries available during the exchange period, just as in Condition ED10 of Experiment 2, but in the absence of a corresponding visual display of LEDs. During exchange periods, which occurred at the end of each 10-trial session, each peck on the illuminated exchange key produced 2-s access to grain (the LEDs remained dark). Condition LED was identical to Condition ED10 of Experiment 2. Condition LILD (large immediate/large delayed) involved a choice between three LEDs delivered immediately and three LEDs delivered after a 6-s delay. Trials and exchange periods were scheduled as in Condition LED. Table 3 summarizes the sequences of conditions and the number of sessions conducted under each.

Table 3

Experimental conditions, order of exposure, key assignments, and number of sessions per condition for each bird in Experiment 3.

Bird	Condition	Large or delayed reinforcer key	Number of sessions
1857	NLED (probe)	right	2
	LED	right	44
	LILD	right	68
	LED	right	22
	NLED	right	44
	NLED	left	42
	LED	left	62
	LED	right	22
	LED	left	30
1732	NLED (probe)	right	2
	LED	right	16
	LILD	right	22
	LILD	left	122
	LILD	right	60
	LED	right	32
	NLED	right	52
	NLED	left	32
	LED	right	40
	LED	left	80[a]
	LED	right	32
1855	NLED (probe)	right	2
	LED	right	36
	LILD	right	80[a]
	LED	right	24
	NLED	right	80[a]
	NLED	left	80[a]
	LED	right	42
	LED	left	100
	LED	right	66

[a] Did not meet stability criteria.

Experiment 3 began immediately after completion of the final condition of Experiment 2. Under the first two conditions of Experiment 3, the key associated with the larger amount of food was the same as that in the final condition of Experiment 2. All birds were initially exposed to Condition NLED for two sessions. Next, all birds were exposed to Condition LED, followed by Condition LILD. The remaining conditions occurred in different sequences for different birds. Each condition was in effect for at least 20 sessions, using the stability criteria described earlier.

Results

Figure 6 shows the number of large and delayed reinforcer choices across experimental conditions in Experiment 3. All 3 birds preferred the option that resulted in the greater amount of food during the initial two-session exposure to Condition NLED at levels comparable to the immediately prior condition (ED10, Experiment 2). All birds continued to prefer the large-reinforcer option when the LEDs were reinstated during Condition LED. During Condition LILD, when the number of LEDs (and overall amount of food) did not differ between options, preference shifted toward indifference, although 2 birds (1732 and 1855) continued to prefer the delayed LEDs.

When the self-control arrangement (Condition LED) was reintroduced following the LILD conditions, choice of the delayed LEDs was enhanced in all birds. This effect was most pronounced in Bird 1857, whose choice patterns shifted from approximate indifference during Condition LILD back to favoring the delayed three LEDs during Condition LED.

During the next pair of conditions (NLED), in which the LEDs remained dark and inoperative, large-reinforcer choices declined in all birds. A seeming exception was the performance of Bird 1857, who continued to prefer the option that resulted in a larger amount of food. Preference for this key persisted, however, even when it resulted in a smaller amount of food during the next condition in which contingencies were reversed on the choice keys, suggesting a possible key bias.

For 2 birds (1857 and 1732), reinstatement of the LEDs during the final sequence of con-

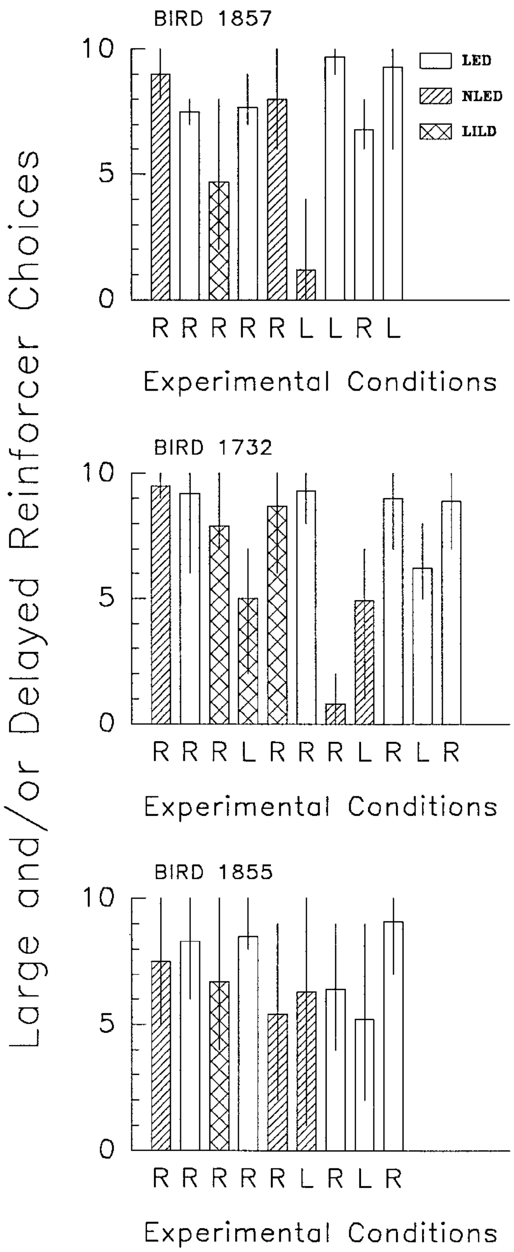

Fig. 6. Mean number of large or delayed reinforcer choices per session across all conditions of Experiment 3. Choices are plotted for the option that produced the greater amount of food during Condition NLED (no LEDs illuminated) and the delayed three LEDs during Conditions LED (self-control arrangement with illuminated LEDs) and LILD (choice between an immediate and a delayed large reinforcer). The key assignment (L for left, R for right) for the plotted option is indicated under each bar. Values are means from the last 10 sessions of each condition, except for the first NLED condition, which lasted only two sessions. Vertical lines show the range of values used to determine the mean.

ditions (LED) produced a shift in choice patterns favoring the option that resulted in the delayed three LEDs and a greater amount of food. In general, preference for the larger reinforcer was maintained across reversal conditions, although some position biases were evident in each bird's responding. Reinstatement of the LEDs did not alter the choice responding of Bird 1855, although in the final exposure to Condition LED this bird preferred the delayed larger reinforcer.

DISCUSSION

Excluding the initial two-session exposure to Condition NLED, the birds usually showed stronger or more reliable preference for the option that produced a greater amount of food when choices also resulted in the illumination of a corresponding number of LEDs (Condition LED) than when LEDs remained dark (Condition NLED). Thus, the illumination of LEDs enhanced choice of the alternative that resulted in a greater amount of food.

Choices were relatively insensitive to delays in LED presentation. During Condition LILD, with delays to and amount of food equal for both options, no bird preferred the immediate presentation of three LEDs over the delayed presentation of three LEDs. Birds did, however, choose the delayed presentation of three LEDs more often when the alternative was an immediate delivery of a single LED (Condition LED) than when the alternative was an immediate delivery of three LEDs (Condition LILD). This suggests greater sensitivity to the number of LEDs than to delays in LED presentation. In fact, with respect to the LEDs, there was little evidence of delay sensitivity of the sort characteristic of studies with food reinforcement and pigeon subjects. A more precise characterization of the role of the LEDs in the present procedures awaits further research.

EXPERIMENT 4

Collectively, the results of Experiments 1 through 3 suggest that delays to exchange periods predominate over delays to LED presentation in determining pigeons' choice patterns. Under most conditions of Experiment 2 and all conditions of Experiment 3, however, delays to exchange periods were not directly manipulated. Perhaps a general insensitivity to reinforcer delay developed over the course of these experiments (e.g., Mazur & Logue, 1978). This possibility was examined in Experiment 4 by assessing choices during self-control arrangements that were similar to some conditions in Experiments 1 and 2, in which the immediate delivery of a single LED sometimes resulted in quicker access to the exchange period. In this way, control by exchange delays could be directly assessed. If choices were governed primarily by delays to the exchange period, then preference should reverse in favor of the small reinforcer when it produces the exchange period more quickly. If, on the other hand, a general insensitivity to delay had developed during earlier experiments, then choice responding should be roughly similar in the two types of conditions.

METHOD

Subjects and Apparatus

The 3 pigeons from Experiment 3 served as experimental subjects. Housing, feeding arrangements, and apparatus were the same as in the previous experiments.

Procedure

Experiment 4 began after completion of Experiment 3. There were two types of experimental conditions during Experiment 4. Condition ED (equal delay) was identical to Condition ED1 of Experiment 2, except that exchange periods occurred 10 s from either choice. Condition UD (unequal delay) differed from Condition ED in that the exchange period began 0.1 s after small-reinforcer choices and 10 s after large-reinforcer choices. Table 4 shows the order of exposure to conditions and the number of sessions conducted in each. For Birds 1732 and 1857, key assignments were constant throughout the experiment. Key assignments were inadvertently reversed between the first and second phases for Bird 1855 (see Table 4). Each condition was in effect for at least 20 sessions, using the stability criteria described earlier. In addition, because of strong carryover effects from immediately prior conditions, no condition ended until each alternative was chosen at least 10 times.

Table 4

Experimental conditions, order of exposure, key assignments, and number of sessions per condition for each bird in Experiment 4.

Bird	Condition	Large reinforcer key	Number of sessions
1857	ED	left	70
	UD	left	20
	ED	left	80
1732	ED	right	64
	UD	right	28
	ED	right	90
1855	ED	right	42
	UD	left	26
	ED	left	98

Results and Discussion

Figure 7 shows the number of large-reinforcer choices across all experimental conditions. In all 3 birds, responding favored the delayed three LEDs over the immediate single LED during the initial exposure to Condition ED (when exchange delays were equal). During Condition UD, in which choice of the small reinforcer resulted in quicker access to the exchange period, preference in all birds reversed in favor of the immediate single LED. During the final 10 sessions of this condition, Bird 1732 chose the small reinforcer exclusively, and Birds 1857 and 1855 each chose the large reinforcer only once. When reexposed to Condition ED, preference for the large reinforcer was recovered in all birds.

These results provide no evidence of generalized insensitivity to reinforcement delay. Instead, consistent with the results of previous experiments with pigeons and humans and with those of Experiments 1 and 2, choice patterns were strongly influenced by differences in delays to the exchange period between options. Birds preferred the delayed large reinforcer (three LEDs) when delays to the exchange period were equal (Condition ED) but preferred the immediate small reinforcer (one LED) when that choice also resulted in quicker access to exchange periods and hence to food (Condition UD).

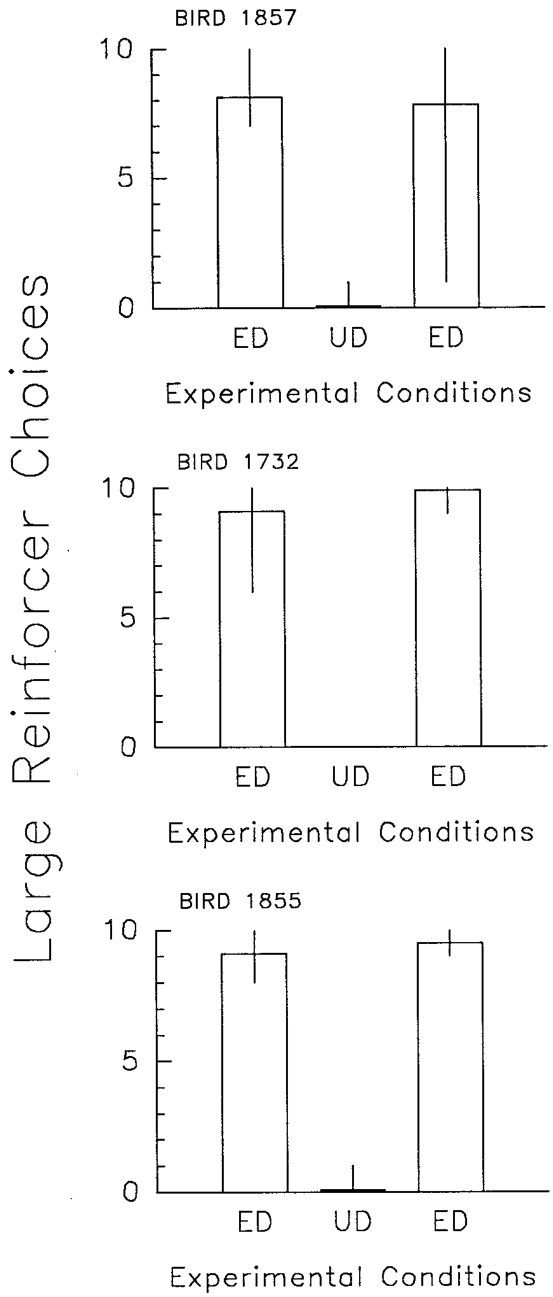

Fig. 7. Mean number of large-reinforcer choices per session across conditions of Experiment 4 with equal (ED) or unequal (UD) delays to the exchange period. Values are means from the last 10 sessions of each condition. Vertical lines show the range of values used to determine the mean.

GENERAL DISCUSSION

In the present series of experiments, the degree to which self-control was observed depended on the delays to the exchange periods. In Experiment 1, when delays to exchange periods favored small-reinforcer choices, self-control was rarely seen (Figure 2). In Experiment 2, when delays to exchange periods were equated for both options, self-control increased. In the terminal condition of Experiment 2 (ED10), 4 of 6 birds preferred the larger, more delayed reinforcer to the smaller, more immediate reinforcer (Figure 5). In Experiment 4, birds preferred a single immediate LED to three delayed LEDs when choice of the former option also resulted in quicker access to the exchange period, but preferred the delayed three LEDs to the immediate single LED when the delays to the exchange period were equal (Figure 7).

Manipulation of delays to exchange periods produced similar preference reversals in a recent study with human subjects (Hyten et al., 1994). As in the present experiment, choices in the Hyten et al. study were insensitive to delays to token presentation, but were sensitive to delays to the exchange period. Thus, self-control and impulsiveness varied as a function of delays to the exchange period. Taken together, these results suggest that delays to token reinforcers (LEDs or points) are less critical than delays to periods when those token reinforcers can be exchanged for other reinforcers (food or money).

The insensitivity to delays in LED presentation that was demonstrated repeatedly in the present series of experiments is similar to the insensitivity to delays in point delivery that is frequently seen with human subjects. Indeed, by treating the LEDs as the reinforcers that define self-control (as points are treated in analogous experiments with humans), the levels of self-control observed with pigeons in the present experiments are comparable to those reported in prior studies with humans (Logue, 1988). This raises the possibility that previously reported differences between pigeons and people on self-control procedures may have more to do with the ways in which self-control has traditionally been defined than with genuine species differences in behavioral process. When the procedures under which self-control in pigeons and humans is studied are more similar, as in the present research, pigeons' choices come to resemble more closely those normally seen in humans (i.e., they show a greater degree of self-control). This is not to imply that all differences between pigeon and human behavior studied in the laboratory are procedural artifacts; important differences certainly exist. But only by studying different species under circumstances as similar as possible can we possibly discover the nature and extent of those differences. The present series of experiments is a step in this direction.

Although the reinforcing function of the LEDs was never directly evaluated in the present study, there are several reasons to suspect that the LEDs did function as conditioned reinforcers. First, the training histories and LED arrangements closely resembled the token reinforcer paradigm (Malagodi, 1967). Although birds in the present study did not directly manipulate the LEDs (as subjects often do in token reinforcement studies), it is not clear that such handling enhances reinforcing efficacy. Also, the long latencies characteristic of first-trial choices and shorter latencies once tokens were present (Experiment 1, Figure 4 and Experiment 2, not shown) resemble previous findings with token reinforcement in chimpanzees (Kelleher, 1958) and rats (Malagodi et al., 1975; Waddell et al., 1972; Webbe & Malagodi, 1978). Informal observations revealed that all birds did occasionally orient toward the LEDs when they were presented and often pecked at them during the ITI and prior to exchange periods. Pecking is often elicited by stimuli paired with food (Schwartz & Gamzu, 1977), stimuli that also would come to have reinforcing properties (Gollub, 1977). The LED illumination might be expected to function as conditioned reinforcement because the accumulation of LEDs across trials that preceded an exchange period was correlated with reductions in the delay to food (Fantino, 1977).

Although the precise reinforcing function of the LEDs cannot be specified with certainty, it is no more mysterious than is the function of points delivered in similar experiments with human subjects. Points are often presumed to function as reinforcers, even in the absence of explicit instructions (e.g., Logue et al., 1986). Indeed, human subjects typically have extensive histories with points and numbers outside of the laboratory. These histories likely establish precise discriminations of more from fewer points over a wide range of absolute numbers of points. If points are delivered as reinforcers, such histories may also enhance sensitivity to the cumulative amount of reinforcement—sensitivity that may be related to the maximization and self-control often seen in human subjects. The present finding of self-control in organisms that did not have such extensive verbal and social histories suggests that training circumstances provided within the token reinforcer arrangement may be sufficient to produce the type of self-control seen here.

In a token reinforcement procedure like that used in the present experiments, the amount of the terminal reinforcer that will be available during exchange periods is often an aggregate result of numerous choices made prior to the exchange period. Tokens may facilitate self-control by bringing choices under the control of their aggregate effect on the amount of the terminal reinforcer available during the exchange period. Token delivery may enhance choice of the larger reinforcer in this context, not through a direct reinforcing function but by providing a stimulus (number of tokens) that is differentially correlated with deferred choice outcomes regarding amounts of the terminal reinforcer. In the present study, the display of illuminated LEDs earned during experimental sessions corresponded precisely with the cumulative amount of food available during the subsequent exchange period, a seemingly ideal arrangement for engendering this type of control. In this case, choice of the delayed three LEDs may not represent reinforcement by LEDs at all. Rather, the LEDs may have provided a more immediate discriminative basis for maintaining choices that resulted in more food during the exchange period.

The importance of the LEDs in maintaining choices that resulted in a greater amount of food was demonstrated during Experiment 3, when choice was compared across conditions with and without LED illumination as a consequence. The function attributed to the LEDs here resembles the *marking* and *bridging* mechanisms that have sometimes been proposed to account for the effects of stimuli present during delays between behavior and reinforcing consequences in enhancing differential control by those consequences (see Williams, 1994, for a review). This interpretation is also consistent with Logue and Mazur's (1981) finding that overhead lights that were differentially correlated with the large-reinforcer delay period facilitated self-control in pigeons.

Preference for the larger, more delayed reinforcer may have arisen in the present study as a result of stimuli (LEDs) that were differentially correlated with the cumulative outcomes of choices. Such stimuli may facilitate self-control in a manner similar to self-generated rules reported by human subjects, rules that similarly correspond to the outcomes of alternative choice options in relation to overall obtained reinforcement. Verbal stimuli of this kind may also engender self-control outside the laboratory (see Skinner, 1953, chap. 15). The token reinforcer arrangement may bring choices under control of the amount of a deferred terminal reinforcer by providing more immediate stimuli (tokens) that correspond to that reinforcer, in the same way that verbal stimuli such as checks on a list, graphic displays of energy use, or daily weight records bring human behavior under the control of long-term outcomes. In both cases, such stimuli may function as conditioned reinforcers; indeed, they occur response dependently. Their critical function, however, even when they are chosen, is their discriminative effect on subsequent behavior that is itself important because of its relationship to some other deferred reinforcer.

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